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DESIGN AND FABRICATION OF SMART WHEELCHAIR

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***Abstract*— The Design and Fabrication of a Smart Wheel Chair** aim to develop an intelligent mobility system that assists physically challenged and elderly users in moving independently with minimal effort. The mechanical structure is designed using lightweight and strong materials to ensure stability, durability, and user comfort. Control inputs such as a joystick and voice-based commands allow easy operation, while the sensor system continuously monitors the surrounding environment and prevents collisions, thereby improving safety during movement. The fabrication process involves mechanical assembly of the wheelchair frame, installation of motors and wheels, and interfacing of electronic components with embedded software. The control program regulates speed, direction, and obstacle avoidance to provide smooth and reliable navigation. Testing results indicate that the smart wheelchair operates effectively in indoor environments and reduces physical strain on users. The proposed system is cost-effective, user-friendly, and adaptable, making it suitable for hospitals, rehabilitation centres and personal mobility applications, with scope for future upgrades such as IoT connectivity and health monitoring.

***Keywords*—** Smart Wheelchair, IOT, joy stick, Embedded Systems, DC Motor, Obstacle Detection, Assistive Technology, ArduinoMicrocontroller, Automation, Sensor-Based Control .

INTRODUCTION

Industrial automation involves the application of control systems, machinery, and information technologies to operate industrial processes with minimal human intervention. Over recent decades, automation has significantly transformed manufacturing by improving productivity, consistency, accuracy, and operational efficiency. Industries such as automotive, food processing, packaging, electronics, and logistics increasingly rely on automation to meet rising market demands and remain competitive.

The primary objective of industrial automation is to ensure consistent product quality while reducing dependence on manual labor. Automated systems enable continuous operation, minimize human error, and enhance process reliability. With advancements in embedded systems, sensors, and software-based control, automation has evolved to include intelligent decision-making capabilities, allowing industries to manage complex operations efficiently.

PROBLEM IDENTIFICATION

Mobility is a fundamental requirement for independent living, social interaction, and overall well-being. Physically challenged individuals and elderly people often face serious mobility issues due to paralysis, muscular weakness, joint disorders, spinal injuries, or age- related degeneration. Conventional manual wheelchairs demand continuous physical effort from the user or assistance from caregivers, which limits independence and causes fatigue over prolonged use. Users with weak upper limbs are unable to propel manual wheelchairs efficiently, making them dependent on others for basic movement. In indoor environments such as homes, hospitals, and rehabilitation centres, a wheelchair through narrow spaces and corridors becomes challenging without assistance. The lack of powered movement restricts freedom and reduces confidence among users. These mobility challenges highlight the necessity for an improved wheelchair system that enables smooth, independent, and reliable movement with minimal physical effort.

EXISTING SYSTEM

The existing smart wheelchair systems are designed to assist individuals with physical disabilities by providing enhanced mobility, independence, and safety. Traditional wheelchairs require manual effort or basic joystick control, which may not be suitable for all users, especially those with severe motor impairments. To overcome these limitations, modern smart wheelchairs incorporate advanced technologies such as microcontrollers, sensors, and wireless communication modules.

In current systems, the primary mode of control is typically a joystick-based interface. The user can move the wheelchair forward, backward, left, or right by manipulating the joystick. This system is simple and effective for users with sufficient hand control. However, for users with limited mobility in their hands, alternative control methods such as voice recognition, head movement, or touch-based controls are also implemented in some advanced models. These systems aim to provide flexibility and accessibility based on the user's physical capabilities.

Most existing smart wheelchairs use microcontrollers like Arduino or ESP-based controllers to process input signals and control the motors. The controller receives commands from input devices and sends appropriate signals to the motor driver, which in turn drives the DC motors connected to the wheels. The motor driver plays a crucial role in regulating speed and direction, ensuring smooth and controlled movement of the wheelchair.

Obstacle detection and avoidance are important features in many current smart wheelchair systems. Ultrasonic sensors are commonly used to detect obstacles in the path of the wheelchair. When an obstacle is detected within a certain distance, the system either alerts the user or automatically stops the wheelchair to prevent collisions. Some advanced systems also include infrared sensors and cameras for better environmental awareness and navigation.

Wireless communication is another key component of existing systems. Technologies such as Bluetooth and Wi-Fi are used to control the wheelchair remotely using smartphones or other devices. Mobile applications allow caregivers or users to monitor and control the wheelchair, providing an additional layer of convenience and safety. In some systems, GPS modules are integrated to track the location of the wheelchair, which is especially useful for outdoor navigation and emergency situations.

Battery management is a critical aspect of smart wheelchair systems. Most systems use rechargeable batteries, typically 12V or 24V, to power the motors and electronic components. Voltage regulators are used to provide appropriate voltage levels to different components such as sensors, controllers, and communication modules. Efficient power management ensures longer battery life and reliable operation of the wheelchair.

Despite these advancements, existing systems have certain limitations. Many smart wheelchairs are expensive, making them inaccessible to a large portion of users. Additionally, some systems are complex and require technical knowledge for operation and maintenance. Sensor accuracy can also be affected by environmental conditions, leading to reduced reliability in obstacle detection. Furthermore, not all systems are customizable, which limits their adaptability to individual user needs.

In conclusion, the existing smart wheelchair systems have significantly improved mobility assistance by integrating modern technologies such as sensors, microcontrollers, and wireless communication. While they offer enhanced safety, control, and convenience, there is still room for improvement in terms of cost, usability, and adaptability. Future developments aim to create more affordable, user-friendly, and intelligent systems to better serve individuals with disabilities.

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PROPOSED SYSTEM

The proposed smart wheelchair system is designed to provide a more advanced, user-friendly, and efficient mobility solution for physically challenged individuals. Unlike the existing systems, this model focuses on improving safety, automation, and ease of control by integrating multiple technologies such as IoT, sensors, and intelligent control mechanisms. The system aims to enhance independence and reduce the need for continuous assistance from caregivers.

In this proposed system, the central controller is an ESP32 microcontroller, which is responsible for managing all operations of the wheelchair. The ESP82 is selected due to its high processing capability, built-in Wi-Fi and Bluetooth features, and low power consumption. It acts as the brain of the system, receiving input signals, processing data from sensors, and controlling the output devices such as motors and communication modules.

The wheelchair is controlled using multiple input methods to accommodate different types of users. A joystick module is provided for manual control, allowing users to navigate easily in all directions. Additionally, a mobile application is integrated using Bluetooth or Wi-Fi connectivity, enabling remote operation of the wheelchair. This feature is especially useful for caregivers to control or monitor the wheelchair when required. Voice control can also be optionally implemented to assist users with limited hand movement.

For safety enhancement, the system incorporates ultrasonic sensors for obstacle detection. These sensors continuously monitor the surroundings and detect any objects in the path of the wheelchair. If an obstacle is detected within a predefined distance, the system automatically stops the wheelchair or alerts the user through a buzzer. This prevents accidents and ensures safe navigation in crowded or unfamiliar environments.

An important addition in the proposed system is the integration of a heartbeat sensor. This sensor continuously monitors the user's heart rate and sends the data to the ESP82. In case of abnormal heart rate conditions, the system can send alerts to caregivers or family members via a mobile application or IoT platform. This feature adds a health monitoring aspect to the wheelchair, making it more intelligent and supportive for users with medical conditions.

The motor control system consists of DC motors connected to a motor driver module. The ESP82 sends control signals to the motor driver, which regulates the speed and direction of the motors. This ensures smooth and precise movement of the wheelchair. The system is designed to handle different terrains and provide stable motion control.

Power supply is provided using a rechargeable 12V battery. A voltage regulation unit is used to distribute appropriate voltage levels to different components such as the ESP82, sensors, and communication modules. Efficient power management techniques are implemented to increase battery life and ensure uninterrupted operation of the system.

The proposed system also includes IoT functionality for real-time monitoring. Data such as location, heartbeat, and system status can be transmitted to a cloud platform. This allows caregivers to track the wheelchair and monitor the user's condition remotely. In emergency situations, alerts can be sent instantly, improving response time and safety.Compared to existing systems, this proposed smart wheelchair offers several improvements. It provides multi-mode control (joystick, mobile app, and voice), enhanced safety through obstacle detection, health monitoring using sensors, and remote access via IoT. Additionally, the use of ESP82 reduces system complexity and cost while improving performance.

In conclusion, the proposed smart wheelchair system is a comprehensive solution that combines mobility assistance with safety, health monitoring, and smart connectivity. It addresses the limitations of existing systems by offering a more affordable, flexible, and intelligent design. This system has the potential to significantly improve the quality of life for individuals with disabilities by providing greater independence and security.

I. FEATURES OF PROPOSED SYSTEM

a) **Multi-Mode Control System:** The wheelchair supports different control methods such as joystick control, mobile application control (via Bluetooth/Wi-Fi), and optional voice control. This allows users with different physical abilities to operate the wheelchair easily.
b) **ESP82-Based Smart Controller:** The system uses an ESP82 microcontroller, which offers high-speed processing, built-in Wi-Fi and Bluetooth connectivity, and low power consumption. It efficiently manages all system operations.
c) **Heartbeat Monitoring System:** A heartbeat sensor is integrated to continuously monitor the user's heart rate. In case of abnormal readings, alerts can be sent to caregivers, improving medical safety.
d) **IoT-Based Remote Monitoring:** The system can send real-time data such as location, health status, and wheelchair condition to a cloud platform. Caregivers can monitor the user remotely through a mobile app.
e) **Wireless Communication:** Built-in Wi-Fi and Bluetooth enable seamless communication between the wheelchair and external devices like smartphones for control and monitoring.
f) **Motor Control with Driver Circuit:** DC motors are controlled using a motor driver module, ensuring

smooth speed control and precise directional movement.

g) **Rechargeable Battery System:** The wheelchair is powered by a 12V rechargeable battery with a voltage regulation unit to provide stable power to all components.

h) **Emergency Alert System:** In case of emergency situations (like health issues or system failure), the system can send alerts to predefined contacts for immediate assistance.

i) **User-Friendly Design:** The system is designed to be simple, easy to operate, and adaptable for different users, reducing dependency on others.

j) **Low Cost and Efficient Design:** Compared to existing systems, the proposed design focuses on affordability while maintaining high performance and reliability.

II. OBJECTIVES OF PROPOSED SYSTEM

The main objective of the proposed smart wheelchair system is to provide independent and efficient mobility for physically challenged individuals by integrating advanced technologies. The system is designed to support multiple control methods such as joystick, mobile application, and voice commands to ensure ease of use for different types of users. It aims to enhance user safety by incorporating obstacle detection using sensors to avoid collisions during movement. Additionally, the system focuses on health monitoring by integrating a heartbeat sensor to track the user's condition and provide alerts in case of abnormalities. The inclusion of IoT technology enables remote monitoring and tracking of the wheelchair, allowing caregivers to supervise the user in real time. The system also ensures smooth and precise movement through efficient motor control and is powered by a reliable battery with proper voltage regulation. Furthermore, the design emphasizes affordability, user-friendliness, and quick emergency response, making the wheelchair a comprehensive and practical solution for improving the quality of life of individuals with disabilities.

Methodology

The design and fabrication of smart wheel chair is developed by first selecting suitable components including ESP82, ultra sonic sensors, a servo motor, and pressure monitoring sensor, joy stick, motor controller and blue tooth module.

a) Problem Identification

The difficulties faced by physically challenged and elderly people using manual wheelchairs are studied. Issues such as high physical effort, lack of safety, and dependence on others are identified. This helps in defining the objectives of the smart wheelchair system

b) Literature Survey

Existing wheelchair systems and related research papers are reviewed. Various control methods, sensors, and automation techniques are analyzed. The limitations of current systems are noted for improvement

c) Requirement Analysis

User needs such as easy control, safety, affordability, and comfort are identified. Functional and non-functional requirements of the system are defined. This step ensures the design meets real-world usage conditions.

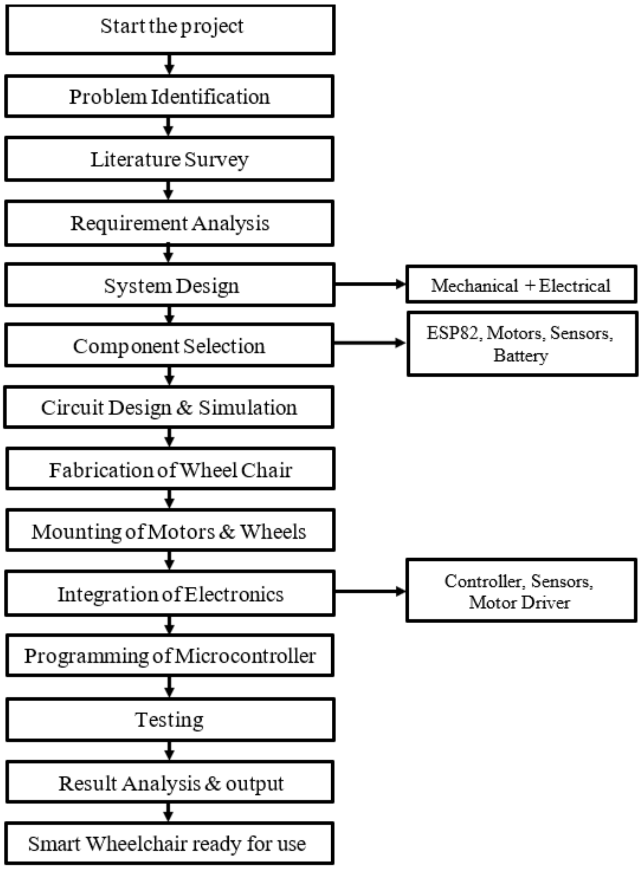

Fig – 1 - Methodology

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d) System Design

The overall system architecture is designed including mechanical and electrical parts. The frame structure, motor placement, and control layout are planned. Block diagram and circuit design are prepared.

e) *Component Selection*

Suitable components like ESP32, DC motors, motor driver, sensors, and battery are selected. Selection is based on cost, availability, efficiency, and power requirements. This ensures reliable system performance.

f) Circuit Design and Simulation

The electronic circuit is designed and connections are verified. Simulation helps in checking correctness before hardware implementation.\

g) *Fabrication of Wheelchair Frame*

The wheelchair frame is fabricated using mild steel for strength and durability. Wheels and motor mounts are fixed properly. Mechanical stability and load capacity are ensured.

h) Integration of Electronics

All electronic components are mounted on the wheelchair. Proper wiring 18 connections are made between controller, motors, sensors, and power supply. Care is taken to avoid loose connections.

i) Programming of Controller

The Arduino is programmed to control motor movement and sensor operation. Logic for obstacle detection and automatic stopping is implemented. The program is tested for accuracy.

j) Testing and Debugging

The complete system is tested under different conditions. Errors in hardware and software are identified and corrected. Smooth movement and safety features are verified.

k) Performance Evaluation

The performance of the smart wheelchair is evaluated based on speed, stability, and obstacle detection. Battery efficiency and user comfort are analyzed. Results are compared with expected out comes.

l) Result and Conclusion

Final results are documented after successful testing. The system proves to be safe, efficient, and user-friendly. Conclusions are drawn based on performance and objectives achieved.

MODELING AND ANA**LYSIS**

The modeling and analysis of a smart wheelchair involve designing and evaluating its mechanical, electrical, and control systems to ensure efficient and safe operation. The wheelchair is modeled as a differential drive system using two DC motors, where movement is controlled by varying the speed and direction of each wheel. The mechanical structure is designed to provide stability and support the user's weight. In electrical modeling, components such as the battery, motor driver, sensors, and microcontroller are interconnected, with a 12V power supply regulated for proper functioning. The control system, typically using an ESP82 or Arduino, processes inputs from a joystick and ultrasonic sensors to control movement. The joystick allows directional control, while sensors detect obstacles by measuring distance. If an obstacle is detected, the system automatically stops or avoids collision. The analysis of the system is carried out based on parameters like response time, accuracy of obstacle detection, motorefficiency.

Fig -2 - 3D view of wheelchair base.

ARCHITECTURE OF THE SMAR WHEEL CHAIR.

The architecture of a smart wheelchair is designed as an integrated system that combines mechanical, electrical, and software components to provide safe, efficient, and intelligent mobility for physically challenged individuals. It follows a modular approach where different subsystems such as input, control, processing, output, and power supply are interconnected to work as a single unit. This structured design ensures flexibility, reliability, and ease of maintenance.

At the **input stage**, the system collects data from various devices that provide user commands and environmental information. The primary input device is a joystick, which allows the user to control the movement of the wheelchair in different directions such as forward, backward, left, and right. In addition to manual control, ultrasonic sensors are used to detect obstacles in the path of the wheelchair. These sensors continuously send and receive ultrasonic waves to measure the distance between the wheelchair and nearby objects. Optional inputs like a heartbeat sensor or temperature sensor can also be included to monitor the health condition of the user. These inputs ensure both control and safety during operation.

The **control unit** acts as the brain of the system and is typically implemented using a microcontroller such as ESP32 or Arduino. This unit is responsible for receiving signals from all input devices, processing the data, and generating appropriate output commands. The microcontroller is programmed using embedded C or Arduino IDE, where control algorithms are implemented. It continuously checks for joystick inputs and sensor readings. Based on these inputs, it decides whether the wheelchair should move, stop, or change direction. For example, if the joystick indicates forward movement and no obstacle is detected, the controller allows the motors to run. However, if an obstacle is detected within a certain range, the controller overrides the user command and stops the wheelchair to prevent collision.

The **processing and communication layer** enhances the smart functionality of the wheelchair. In addition to basic control, the ESP32 enables wireless communication through Bluetooth or Wi-Fi. This allows the wheelchair to be controlled remotely using a smartphone application. It also supports advanced features such as real-time monitoring, emergency alerts, and location tracking. Data from sensors can be transmitted to caregivers or family members, improving user safety. This layer plays a key role in transforming a conventional wheelchair into an intelligent assistive device.

The **output stage** consists of actuators such as DC motors and motor drivers. The motor driver is an essential component that acts as an interface between the microcontroller and the motors. Since the microcontroller cannot supply sufficient current to drive the motors directly, the motor driver amplifies the control signals and provides the required power. It controls the speed and direction of the motors using techniques like Pulse Width Modulation (PWM). The DC motors are connected to the wheels and are responsible for the actual movement of the wheelchair. By controlling the rotation of each motor, the system achieves different motions such as straight movement, turning, and stopping.

The **power supply unit** is another critical part of the architecture. A 12V rechargeable battery is typically used to power the entire system. Since different components require different voltage levels, a voltage regulator is used to step down and stabilize the voltage for sensitive devices like the microcontroller and sensors. Proper power management ensures efficient energy usage and longer battery life. It also guarantees stable operation without sudden failures.

The architecture also includes a **safety and feedback mechanism**. The continuous monitoring of sensors ensures that obstacles are detected in real time, reducing the risk of accidents. Feedback from the system, such as buzzer alerts or LED indicators, can inform the user about system status, low battery, or detected obstacles. This improves the overall usability and reliability of the wheelchair.

Finally, the **overall system integration** ensures smooth communication between all modules. Each subsystem works in coordination to provide a seamless user experience. The input devices send signals to the controller, the controller processes the data and sends commands to the output devices, and the motors execute the required movement. At the same time, sensors continuously provide feedback to maintain safety.

Thus, the architecture of the smart wheelchair is a well-organized system that combines input devices, a control unit, communication modules, output actuators, and a power supply to deliver an intelligent, safe, and user-friendly mobility solution. It not only improves independence for users but also enhances safety through automation and real-time monitoring.

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BLOCK DIAGRAM

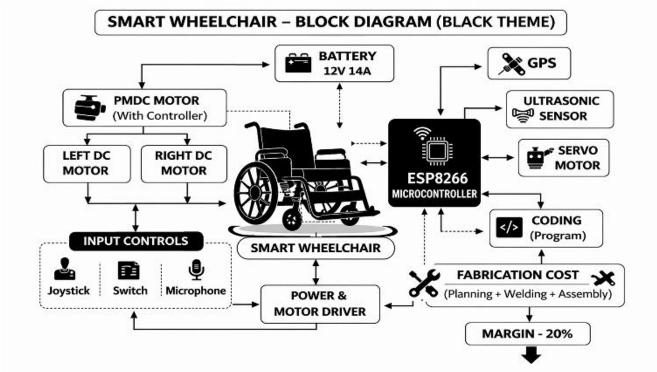

Fig – 3- Block diagram

1. Battery (12V) is connected directly to the motor driver to provide power for driving both DC motors.
2. Battery output is stepped down using a voltage regulator and then connected to the ESP8266 power input (3.3V/Vin).
3. ESP8266 GPIO pins are connected to the motor driver input pins (IN1, IN2, IN3, IN4) to control motor direction.
4. Motor driver output terminals are connected to the left DC motor for movement of the left wheel.
5. Motor driver output terminals are also connected to the right DC motor for movement of the right wheel.
6. Joystick module X and Y output pins are connected to ESP8266 input pins to control direction of the wheelchair.
7. Switch is connected to a digital GPIO pin of ESP8266 for power control or mode selection.
8. Microphone module output is connected to ESP8266 input pin to enable voice control operation.
9. Ultrasonic sensor Trig and Echo pins are connected to ESP8266 GPIO pins for obstacle detection.
10. GPS module TX and RX pins are connected to ESP8266 RX and TX pins respectively for location tracking.
11. Servo motor signal pin is connected to a PWM pin of ESP8266 for controlled movement.

COMPONEN DESCRIPTION

a) Esp82:

The ESP82 acts as the main controller in the smart wheelchair system. It receives input signals from the joystick, sensors, or mobile application and processes them. Based on these inputs, the ESP82 sends control signals to the motor driver to move the wheelchair in the desired direction. It also handles data from sensors like 20 ultrasonic sensors to detect obstacles and improve safety. With its built-in Wi-Fi and Bluetooth, the ESP82 enables wireless control and communication. Overall, it works as the brain of the system, coordinating all operations smoothly.

b) Ultrasonic sensors:

The Ultrasonic Sensor works as the obstacle detection unit in the smart wheelchair system. It continuously sends ultrasonic sound waves and measures the time taken for the echo to return. Using this time, it calculates the distance between the wheelchair and nearby objects. When an obstacle is detected within a set range, it sends a signal to the controller. The controller then stops or adjusts the movement to prevent collisions. Thus, the ultrasonic sensor improves safety and enables smooth navigation.

c) Servo motor:

The Servo Motor is used to provide precise angular movement in the smart wheelchair system. It receives control signals from the controller to rotate to a specific position. This allows accurate control of mechanisms such as sensor positioning or steering support. The servo motor operates based on PWM signals, ensuring smooth and stable motion. It helps improve the functionality and responsiveness of the system. Thus, the servo motor enables controlled and accurate mechanical movement.

d) Camera Module:

The camera module captures real-time images of objects moving on the conveyor belt. These images are used for shape detection and classification through machine vision algorithms. The camera is mounted at a fixed position to ensure consistent image acquisition. Proper lighting conditions are maintained to enhance image clarity and improve the accuracy of image processing results.

e) Battery:

The 12V 14Ah Battery is the main power source of the smart wheelchair system. It supplies electrical energy to all components such as the controller, motor driver, motors, and sensors. The 12-volt output provides sufficient voltage for driving the motors efficiently. With a capacity of 14Ah, it can deliver power for a longer duration, ensuring extended operation. The battery maintains stable power flow for smooth and reliable performance. Thus, it plays a vital role in powering the entire wheelchair system.

f) PMDC motor:

The PMDC Motor (Permanent Magnet DC Motor) is used as the drive motor in the smart wheelchair system. It converts electrical energy from the battery into mechanical motion to rotate the wheels. The motor speed and direction are controlled by the motor driver based on signals from the controller. PMDC motors provide high torque and smooth operation, making them suitable for mobility 21 applications. They ensure efficient movement of the wheelchair in forward, reverse, and turning actions. Thus, the PMDC motor is responsible for the actual motion of the wheelchair.

g) GPS Module:

The GPS module used in a smart wheelchair is an important component for tracking and navigation. It helps in determining the real-time location of the wheelchair using satellite signals. The module continuously receives data from GPS satellites and sends location information such as latitude and longitude to the microcontroller. This data can be used to monitor the user's position through a mobile app or web interface. It is especially useful for caregivers to track the wheelchair in case of emergencies. The GPS module can also be integrated with alert systems to send location details when a panic button is pressed. In some advanced systems, it helps in route planning and navigation assistance. It improves safety by ensuring that the user's location is always known. The module usually works along with communication technologies like GSM or Wi-Fi for data transmission. Overall, the GPS module enhances security, monitoring, and independence in a smart wheelchair system.

h) Input controles:

Input controls in a smart wheelchair refer to the various methods used by the user to control its movement and functions. These controls include devices such as a joystick, touch sensors, voice commands, and sometimes mobile app-based controls. The input control system collects signals from the user and sends them to the microcontroller for processing. Based on the received input, the controller decides the direction and speed of the wheelchair. Joysticks are the most commonly used input control because they are simple and precise. Voice control systems are useful for users who cannot operate physical controls. Some advanced systems also use head movement or gesture-based inputs. These input methods are designed to be user- friendly and require minimal effort. Safety features are often integrated to prevent incorrect commands or sudden movements. Overall, input controls play a vital role in ensuring smooth, safe, and independent operation of a smart wheelchair.

i) joy stick

The joystick used in a smart wheelchair is an essential easily. It helps in controlling the movement in different directions such as forward, backward, left, and right. When the joystick is moved, it sends corresponding signals to the microcontroller. Based on these signals, the motor driver activates the motors to move the wheelchair in the desired direction. Most smart wheelchairs use an analog joystick, which provides precise and smooth control. It is especially useful for physically challenged users as it requires minimal effort to operate. The sensitivity of the joystick can also be adjusted for better control and comfort. It ensures gradual speed changes, which improves safety by avoiding sudden jerks. Due to its compact size, it can be easily mounted on the wheelchair. Overall, the joystick acts as the main interface between the user and the smart wheelchair, enhancing independence and ease of mobility.

CIRCUIT DIAGRAM OF SMART WHEEL CHAIR.

The circuit diagram of the smart wheel chair.

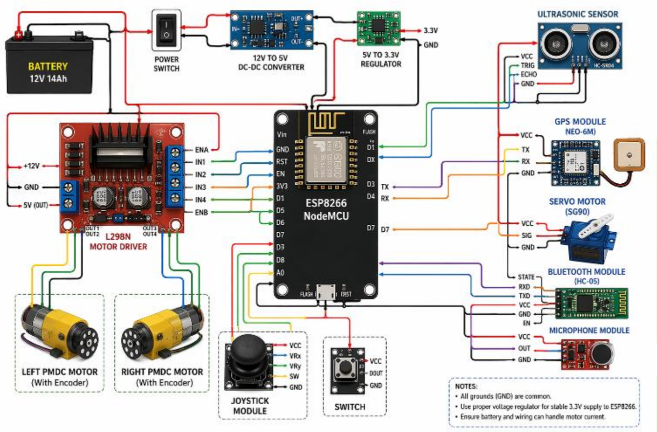

Fig – 4 - Circuit Diagram

I. RESULTS AND DISCUSSION

The smart wheelchair system was successfully designed, fabricated, and tested with all integrated modules. The **ESP8266-based control system** effectively coordinated input controls, sensor data, and motor operations. The wheelchair responded accurately to **joystick inputs**, enabling smooth forward, backward, and turning movements.

The integration of the **ultrasonic sensor** allowed real-time obstacle detection, and the system was able to stop or avoid collisions within a safe distance. The **Bluetooth module (HC-05)** enabled wireless control through a mobile device, providing an alternative to manual control. The **GPS module (NEO-6M)** successfully tracked the location of the wheelchair, which is useful for safety and monitoring purposes.

The **PMDC motors** driven by the motor driver provided sufficient torque for movement, and the system maintained stable performance under normal operating conditions. The power supply unit with voltage regulation ensured consistent operation of all electronic component.

The developed system demonstrates a reliable and efficient smart mobility solution for physically challenged individuals. The combination of **manual (joystick)** and **wireless (Bluetooth, voice)** control makes the system flexible and user-friendly.

Obstacle detection significantly improves safety, especially in indoor environments. However, ultrasonic sensors may have limitations in detecting soft or angled surfaces, which can affect accuracy in some cases.

The use of **ESP8266** provides added advantage due to its built-in Wi-Fi capability, which can be further extended for IoT-based monitoring. The Bluetooth module worked effectively for short-range communication, but its range is limited compared to Wi-Fi.

The PMDC motors performed well, but performance may vary depending on load and battery condition. Efficient battery management is important for longer usage time.

Overall, the system is cost-effective, easy to implement, and suitable for real-time applications. Future improvements can include advanced sensors, AI-based navigation, and improved battery efficiency for enhanced performance.

II. CONCLUSION

The smart wheelchair system was successfully designed and implemented by integrating control, sensing, and communication technologies. The system uses an ESP8266 microcontroller to manage all operations, including user inputs, motor control, and safety features. The wheelchair can be operated using multiple methods such as joystick, Bluetooth, and voice control, making it flexible and user-friendly.

The use of ultrasonic sensors improves safety by detecting obstacles and preventing collisions. The GPS module adds an extra advantage by enabling real-time location tracking. The PMDC motors, controlled through a motor driver, provide smooth and efficient movement of the wheelchair in different directions.

The power supply system with proper voltage regulation ensures stable performance of all components. The addition of a Bluetooth module allows wireless control, making the system more convenient for users.

Overall, the smart wheelchair is a cost-effective, reliable, and efficient solution that enhances mobility and independence for physically challenged individuals. The system can be further improved by adding advanced features like automation, IoT connectivity, and better battery management for enhanced performance in future applications.

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